Workshop on Energy Recovery Linacs

ERL2015

Multipass-ER@CEBAF

F. Méot, BNL
for the BNL-JLab exploratory team

MOTIVATIONS (1/3)

ER operation in ERL-based EIC is characterized by

- large number of linac passes

- high energy *(tens of GeV)*

- high intensity *(10s of mA per beam)*

These are unprecedented operation conditions, performance areas of ERL based collider include

- capability of ensuring multi-MWs beam power

- efficiency of ER

- efficiency of beam transport to dump

MOTIVATIONS (2/3)

- A full-scale multiple-pass ER experiment at CEBAF could include
  - end-to-end bunch transport studies
  - ER efficiency
  - response of RF systems to ER
  - beam dynamics at BBU boundary
- And beyond, it would allow further R&D regarding
  - synchrotron radiation effects
  - full-scale multiple-beam instrumentation
  - etc.

MOTIVATIONS (3/3)

- **A collaboration between national labs, for a project which is the future of NP**

- **A full scale experiment / at the scale of ERL-based EIC parameters :**

  - energy, number of recirculations, synchrotron radiation

- **This is big science : a demonstration of general interest to advanced ERL R/D and future EIC projects, light sources, etc.**

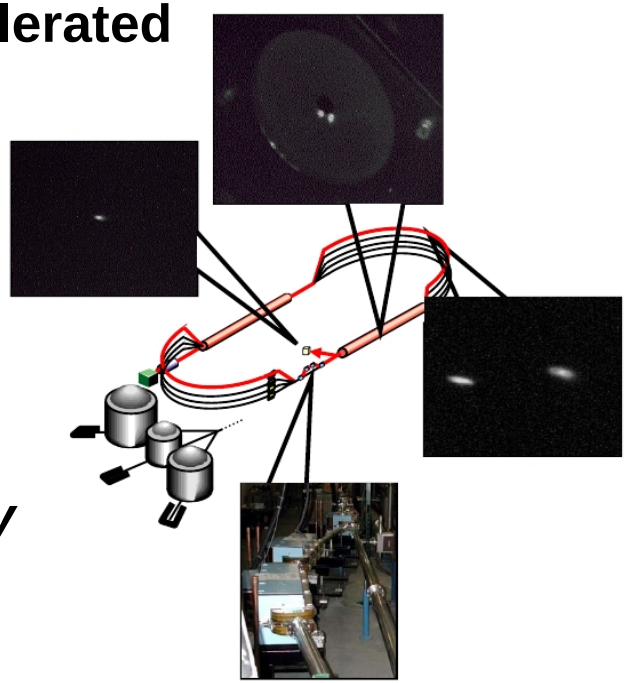
MULTIPASS-ER@CEBAF (1/3)

Reminder : the 2003, 1-pass, 1GeV ER experiment

- **Demonstrated 1 loop ER, and beam dump :** **55 → 555 → 1055 MeV (80μA)**
  20 → 520 → 1020 MeV (1μA)
- **Transverse emittance and momentum spread of accelerated and energy recovered beams were measured in many locations**

  - emittance degradation was observed.
  the cause is to be found in cavity modes

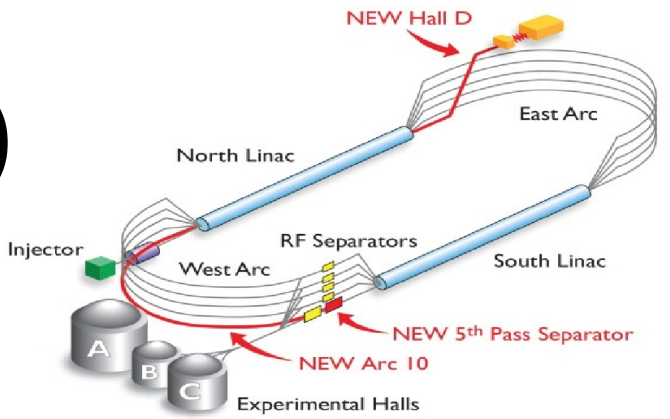
  - degradation of emittance during acceleration was consistent with that during deceleration, thus ER process does not contribute significantly



Measurements were performed on RF system response to energy recovery (gradient and phase stability), at several cavities, in pulsed beam operation

- ER was proven : did zero the power draw from cavities - apart from short end-transients

MULTIPASS-ER@CEBAF (2/3)



- **Acceleration can be 5-pass**
- **Linac energy :**

  - Energy spread on the way down sets limit to top energy (<10^{-3}).

  - Wise : start with low enough energy - 700 MeV/linac
- ***L*inac optics and re-matching to arcs will be part of the work**
- **The phase chicane system can be located in arc 10 region.**

  Placing a beam dump will require removing a cryomodule
- **Beyond ER studies : allows studying SR effects, polarization**

  - possibility to induce momentum spread with off crest acceleration

  - possibility to study 12 GeV with final pass thru North linac

MULTIPASS-ER@CEBAF (3/3) BBU studies

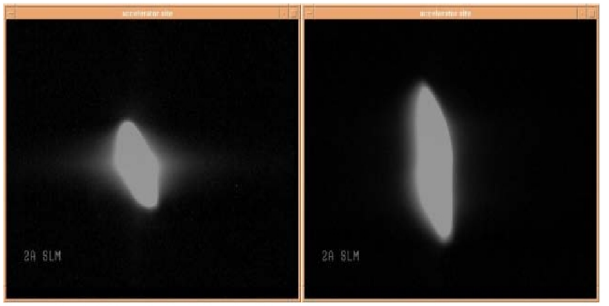


Figure 2: Beam spot well below BBU limit (left) and very close to BBU limit (right) on the SLM.

- **BBU was studied in 2007 with multi-pass recirculated beam : a shorted, HOM Q damper caused 40μA threshold**

- **BBU studies were part of the 12GeV upgrade**

- **Feasibility of exciting BBU in a multiple-pass ER experiment ?**

  - **A 5up + 5down experiment means twice as much current**

  - **Amongst various possibilities to be investigated :**
    - **lower E, increase I, for larger transverse kick**
    - **unscrew filters and remeasure HOM Qs to see if things are reachable**
    - **upgrade a gun**
    - **increase bunch charge**
    - **run in a mode where ER has sufficient efficiency for large-current while limiting power at beam dumps**
    - **“intensity-doubling” coasting, based on a λ/4 phase chicane**

An approach to the cost of ER@CEBAF cf. 2003's experiment

Proposal P-02-102
CEBAF Energy Recovery Experiment

Co-Spokesmen: Alex Bogacz, Andrew Hutton

Equipment Costs

All costs include procurements and labor

Mechanical cost	$172.3 k
Electrical cost	$67.2 k
Total cost	$239.5 k

Installation time ~ 4 weeks

Jefferson Lab — Thomas Jefferson National Accelerator Facility

- ← the 2003 proposal to the Program Advisory Committee

- estimate at that time was ~250k$ to field the experiment. 15 years of escalation at 3% brings this to ~375k$

- for the 5-pass experiment, would need to scale appropriately the delay chicane for the higher energy (~330k$)

- dump and instrumentation are already available. Just need to be relocated.

- add around 1 man-month for a cryomodule to be removed for the test and then reinstalled when test is over.

- Labs involved in the field may be interested to collaborate and contribute

Beyond multiple-pass ER : a test bed of innovative ideas

"Value engineering on multiple-pass FFAG-optics ERL"

- **An EIC-scale construction and beam R&D based on a full-scale FFAG arc, using permanent magnets (e.g., eRHIC style), placed in CEBAF East-arc area**

- **Including :**

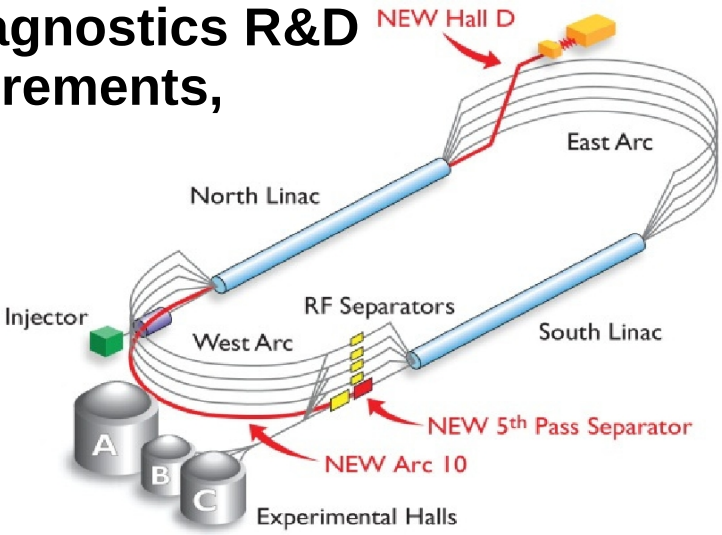
  - **Multiple-pass in an FFAG arc**

  - **possibility of full-scale instrumentation and diagnostics R&D (including, *e.g.*, beam position and TOF measurements, assessment/correction of chromatic effects)**

  - **multiple-pass ER, RF systems response**

  - **SR effects and 6-D beam emittance**

  - **transport of polarization**



- **It would allow teams to build experience/expertise**

GUIDANCE FOR THE DISCUSSION

- **Multipass-ER at CEBAF – FM/BNL (this introduction)**
- **CEBAF 5-pass ERL with FFAG Arc? – A. Bogacz/JLab (15')**
- **eRHIC permanent magnet cross-section – N. Tsoupas/BNL (10')**
- **DISCUSSION (~45 min.)**

~20 min. : A multipass-ER experiment

- primary goal : study eRHIC performance parameters

- what it requires

manpower, investments, scheduling, etc.

~20 min. : FFAG arc

beam studies, instrumentation prototyping and R&D, etc.

REFERENCES

[IPACMEET] M. Spata, M. Tiefenback, F. Pilat, V. Ptitsyn, FMeot, eRHIC ER@CEBAF meeting, IPAC15, May 7.

[KAZIMI] R. Kazimi et al., "*Observation and Mitigation of Multipass BBU in CEBAF*", EPAC 2008, (Genoa, Italy), 2008

[SATOGATA] Todd Satogata, priv. comm.

[SHIN] Ilkyoung Shin, "*Multipass Beam Breakup Study at Jefferson Lab for the 12 GeV CEBAF Upgrade*", Ph.D dissertation. University of Connecticut, 2013.

[HUTTON] Doubling the intensity of an ERL based light source, Andrew Hutton, Jefferson Lab, Newport News, VA23693